nuDrive Accessory

This user guide describes the electrical and mechanical aspects of the nuDrive power amplifier accessory and describes how to use the nuDrive with your motion control board.

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Introduction

Your nuDrive accessory is a complete power amplifier and system interface for use with up to four axes of simultaneous or independent servo or stepper motion control. Ideally suited to industrial and laboratory applications, nuDrive has everything you need to connect motors, encoders, limit switches, I/O and other motion hardware to National Instruments plug-in motion control boards.

Table 1 lists the available nuDrives and describes the properties of each nuDrive.

Table 1. nuDrive Properties

nuDrive Type	Number of Axes	Motor Type	Motion Board Cable Connector	Driver/Amplifier Nominal Bus Voltage	Driver/Amplifier Type	AC Input
4SX-411	4	Stepper (2-phase)	50-pin	40 VDC Bus	Microstepping Driver 4A/phase (peak) IM483	115 V (50/60 Hz)
2SX-411	2	Stepper (2-phase)	50-pin	40 VDC Bus	Microstepping Driver 4A/phase (peak) IM483	115 V (50/60 Hz)
4SX-211	4	Stepper (2-phase)	50-pin	24 VDC Bus	Microstepping Driver 4A/phase (peak) IM483	115 V (50/60 Hz)
2SX-211	2	Stepper (2-phase)	50-pin	24 VDC Bus	Microstepping Driver 4A/phase (peak) IM483	115 V (50/60 Hz)
4CX-001	4	DC Brush Servo	50-pin	48 VDC Bus	DC Brush Servo Amplifier SSA 8/100	115 V (50/60 Hz)

Table 1. nuDrive Properties (Continued)

nuDrive Type	Number of Axes	Motor Type	Motion Board Cable Connector	Driver/Amplifier Nominal Bus Voltage	Driver/Amplifier Type	AC Input
2CX-001	2	DC Brush Servo	50-pin	48 VDC Bus	DC Brush Servo Amplifier SSA 8/100	115 V (50/60 Hz)
4CF-001	4	DC Brush Servo	100-pin	48 VDC Bus	DC Brush Servo Amplifier SSA 8/100	115 V (50/60 Hz)
2CF-001	2	DC Brush Servo	100-pin	48 VDC Bus	DC Brush Servo Amplifier S SA 8/100	115 V (50/60 Hz)

The nuDrive can drive a broad range of servo or stepper motors. For servo motors, nuDrive uses pulse-width modulation (PWM) amplifiers with a user-specified peak output current rating and a DC bus voltage. For stepper motors, nuDrive uses a rugged microstepping bipolar chopper driver. Stepper driver configurations are available in a wide range of user-specified current per phase and voltage settings. In all configurations, power supplies are built in and use standard 115 VAC for operation. Electronics are fan cooled to assure reliable operation.

nuDrive simplifies your field wiring through separate encoder, limit switch, and motor power removable screw terminal connector blocks per axis. The terminal blocks do not require any special wiring tools for installation. The nuDrive connects to ValueMotion PCI and ISA boards via a 50-pin ribbon cable, to ValueMotion PXI boards via a 68-pin cable with bulkhead adapter, and to FlexMotion boards via a 100-pin, high-density interconnect cable.

nuDrive has three levels of amplifier inhibit/disable protection for motion system shut down. The front panel contains both enable and power switches for direct motor inhibiting and system power-down operations. nuDrive also has a host bus power interlock that activates an amplifier inhibit signal if the host computer is shut down or the motion controller interface cable is disconnected. On nuDrives with the emergency stop (E-Stop) option enabled, you can wire a 115 V emergency stop switch to the rear panel I/O connector for remote interlock shut down.

nuDrive is packaged in a rugged lightweight aluminum enclosure that is compatible with 19-inch rack standards. You can also use the nuDrive accessory on the benchtop.

What You Need to Get Started

To set up and use your nuDrive accessory, you will need the following items:

- ❑ The nuDrive accessory and *nuDrive Accessory User Guide*
- ❑ Power cord (IEC type)
- ❑ One of the following National Instruments cables:
  - SH68-68-S shielded cable, part number 185262-02
  - 68M-50F step bulkhead cable adapter, part number 185630-01
  - NB1 ribbon cable, part number 180524-20
  - SH50-50 shielded cable, part number 185319-02
  - SH100-100-F shielded cable, part number 185095-02
- ❑ (Optional) ISO power supply (for FlexMotion boards)

Detailed specifications for the nuDrive accessory are in the *Specifications* section later in this guide.

Safety Information

Warnings ***KEEP AWAY FROM LIVE CIRCUITS. Do not remove equipment covers or shields unless you are trained to do so. Hazardous voltages may exist even when the equipment is turned off. To avoid a shock hazard, do not perform procedures involving cover or shield removal unless you are qualified to do so and disconnect all field power prior to removing covers or shields.***

DO NOT OPERATE DAMAGED EQUIPMENT. The safety protection features built into this device can become impaired if the device becomes damaged in any way. If the device is damaged, turn the device off and do not use until service-trained personnel can check its safety. If necessary, return the device to National Instruments for service and repair to ensure that its safety is not compromised.

Do not operate this equipment in a manner that contradicts the information specified in this document. Misuse of this equipment could result in a shock hazard.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the device. Return the device to National Instruments for service and repair to ensure that its safety features are not compromised.

When connecting or disconnecting signal lines to the nuDrive terminal block screw terminals, make sure the lines are powered off. Potential differences between the lines and the nuDrive ground create a shock hazard while you connect the lines.

Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the nuDrive device can create a shock or fire hazard or can damage any or all of the boards connected to the nuDrive chassis, the host computer, and the nuDrive device. National Instruments is NOT LIABLE FOR ANY DAMAGES OR INJURIES resulting from incorrect signal connections.

Installation and Connector Wiring

Caution ***Be sure to turn off the enable switches and the main AC power to your nuDrive and host computer before connecting to your motion control board.***

Connect the motion control board to the nuDrive interface cable. Wire the motor power, limit switch, encoder, I/O, and E-Stop terminal blocks as per the instructions and diagrams in this manual and/or your specific system requirements. Finally, install the power cord into the rear panel AC connector and plug it into a correctly rated power source.

Note ***For 50-pin ribbon cable interconnection, be certain that the colored indicator strip (pin 1) on the cable between the motion control board and the 50-pin connector on the rear of the nuDrive is properly aligned and inserted on both ends. 100-pin cables are keyed metal-shell style.***

Front Panel Switches and Host Bus Interlock Circuit

There are two lighted rocker switches on the nuDrive front panel, POWER and ENABLE.

The POWER switch energizes the DC bus and the logic (+5 V, +12 V) power supplies and illuminates to indicate that the main AC power is present. If the POWER switch fails to illuminate, check the power cord and main input fuse in the power connector.

The ENABLE switch enables or inhibits the servo amplifiers or stepper drivers. It illuminates to indicate that it is switched on and that the logic power supply +12 V output is functioning.

Either switch can turn off the motors. However, as long as the nuDrive POWER switch is still on, independent power and enable circuits cause the incremental encoders to continue to track motor position while the amplifiers (drivers) are disabled (ENABLE switch off).

☞ **Note** ***The ENABLE switch illuminates whenever it is switched on. It will not indicate that the amplifiers/drivers are disabled under the following conditions: E-Stop active (see*** *E-Stop Terminal Block****), host bus interlock fault, or amplifier/driver protection fault (over current, over temperature, and so on). Conversely, it will not light if the remote enable function is used because the Enable switch is off (see*** *I/O Connectors****).***

The nuDrive has a host bus interlock circuit that monitors the presence of +5 V from the host computer and disables the nuDrive when the voltage disappears or falls out of tolerance. This circuit shuts down the motors by activating the Inhibit, or disable circuit for all axes, when the host computer is disconnected from the nuDrive or inadvertently or unexpectedly shut down.

Rear Panel Connector Wiring

Motor Power Terminal Blocks

For motor power wiring on the ValueMotion and FlexMotion nuDrive, each nuDrive axis has a separate 5-position terminal block with removable screw terminals. There are two types of wiring from the same connector for typical operation. Which of these two configurations you use depends upon whether you are using the servo or stepper version of the nuDrive. Figure 1 shows a typical servo motor configuration pin assignment. Figure 2 shows a typical stepper motor configuration pin assignment.

☞ **Note** ***The dotted loop indicates a shielded cable.***

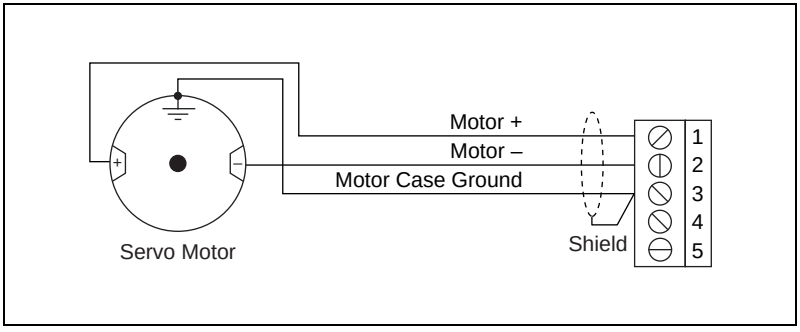


Figure 1. Typical Servo Motor (DC Brush Type) Terminal Block Pin Assignment

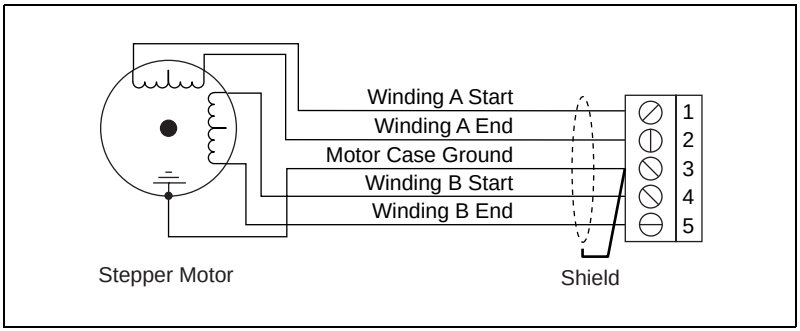


Figure 2. Typical Full-Coil Stepper Motor (2-Phase Type) Terminal Block Pin Assignment

It is recommended you use shielded, 20 AWG wire or larger for the motor power cable. If available, you should connect a case ground wire to pin 3 (Ground/Shield); this helps to avoid ground loops and signal noise problems. (Case ground connects to the motor housing, and not to any of the motor power terminals.)

The stepper version of nuDrive contains bipolar chopper drivers. The stepper motors must be wired in a four-wire configuration as shown in Figure 2. Unused lead wires must be isolated and not connected. See *Stepper Motor Configurations* for additional information on connecting 6- and 8-wire motors and on the alternate half-coil configuration.

Caution ***Never connect unused center taps or winding terminals to pin 3.***

Encoder Terminal Blocks

For quadrature incremental encoder signals, each nuDrive axis has a separate 8-position terminal block with removable screw terminals. Where applicable, nuDrive accepts two types of encoder signal inputs: single-ended (TTL) or differential line driver. You can accommodate open-collector output encoders by using 2.2 kΩ pullup resistors to +5 VDC.

Figure 3 shows the typical encoder wiring pin assignment for single-ended signal input. Figure 4 shows the typical encoder wiring pin assignment for differential line driver signal inputs.

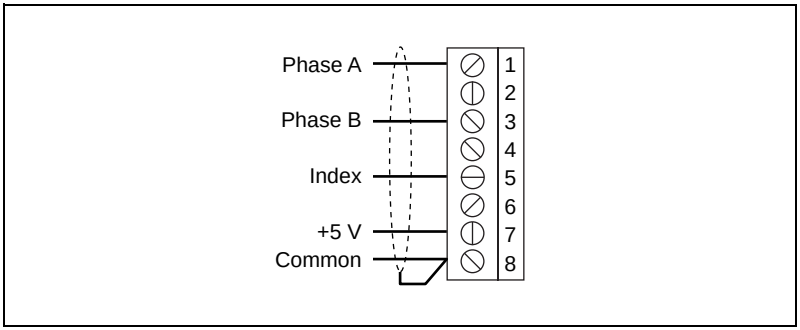


Figure 3. Typical Single-Ended Encoder Wiring Pin Assignment

Note ***The line above some of the signals indicates that that signal is active-low.***

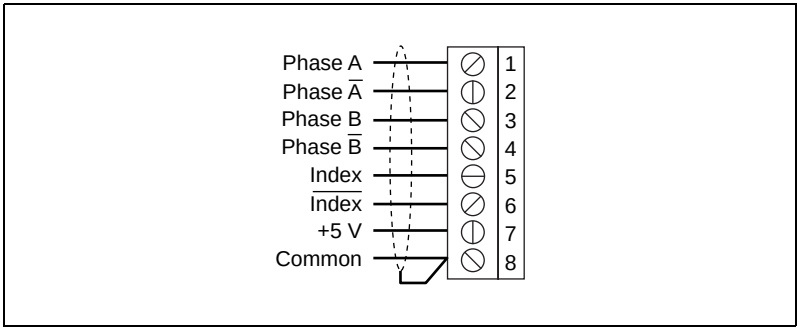


Figure 4. Typical Differential Line Driver Encoder Wiring Pin Assignment

If the encoder cable length is greater than 15 ft, it is recommended you use encoders with line driver outputs for your applications. Power for a +5 V encoder is available on pin 7, generated by a power supply inside the nuDrive.

Note ***If you require other encoder power values, reference an external power supply to the Common (ground) signal on the 8-pin encoder terminal block.***

nuDrives have differential inputs for Phase A, Phase B, and Index signals. You can easily accommodate encoders with various phase relationships by swapping the signals and/or connecting them to the inverting inputs as specific applications require. The index pulse must occur when both Phase A and Phase B signals are logic low, as shown in Figure 5. If the Index pulse is inverted, try reversing the Index and $\overline{Index}$ signals on differential encoders or wiring to the $\overline{Index}$ input with single-ended wiring.

Figure 5 shows the proper encoder phasing for CW (forward) motor rotation.

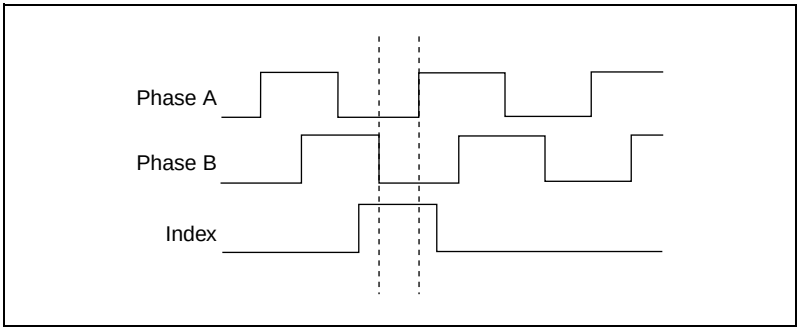


Figure 5. Encoder Signal Phasing, CW Rotation

Servo and closed-loop stepper applications require consistent directional polarity between the motor and encoder for stable operation. The nuDrive standard directional polarity is as follows:

- Positive = forward = clockwise (CW) facing motor shaft
- Negative = reverse = counter-clockwise (CCW) facing motor shaft

Figure 6 shows the clockwise and counter-clockwise motor rotation.

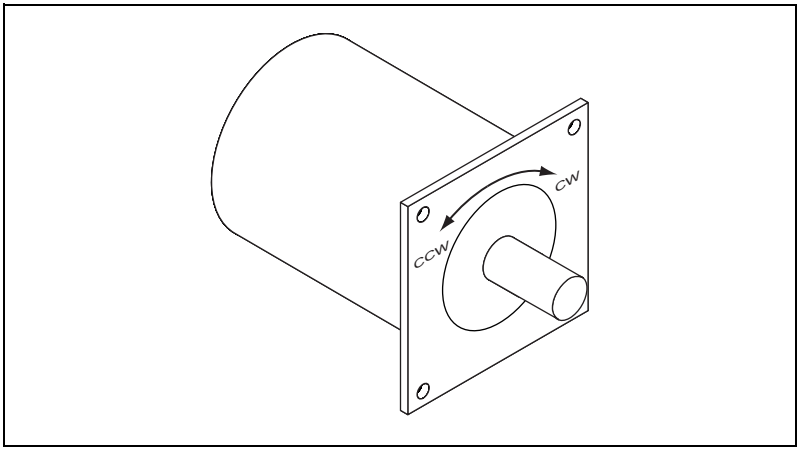


Figure 6. Clockwise and Counter-Clockwise Motor Rotation

When connecting the encoder wiring to your nuDrive accessory, you should use shielded wire of at least 24 AWG. Both analog and digital noise filters filter the encoder inputs in the nuDrive and on the ValueMotion or FlexMotion board itself. You must use cables with twisted pairs and an overall shield for improved noise immunity and enhanced encoder signal integrity. Figure 7 shows twisted pairs in a shielded cable.

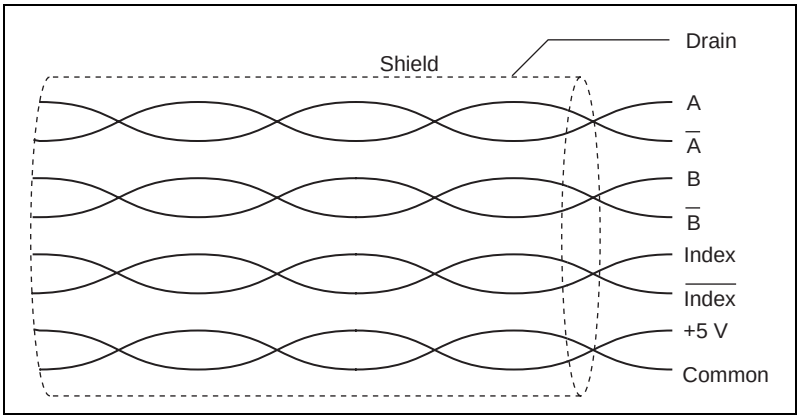


Figure 7. Shielded Twisted Pairs

Note ***If you use an unshielded cable, noise can corrupt the encoder signals, resulting in lost counts, reduced accuracy, and other erroneous encoder and controller operation.***

Limit Switch Terminal Blocks

ValueMotion Configuration

For end-of-travel limit and home switch connections, nuDrive axes have a separate, six-position removable screw terminal connector block. All limit signals are filtered in the nuDrive and debounced on the ValueMotion board to reduce noise sensitivity. When used in conjunction with ValueMotion boards, the limit and home switch inputs are pulled up to +5 V through 3.3 kΩ resistors on the motion control board. For ValueMotion nuDrives, +12 V and +5 V outputs, generated by power supplies within the nuDrive, are available on pins 4 and 5, respectively. These power supply outputs are provided for use in powering active limit switches. Refer to Figures 8 and 9 for examples of passive and active limit switch wiring using the terminal block pin assignments on the ValueMotion nuDrive.

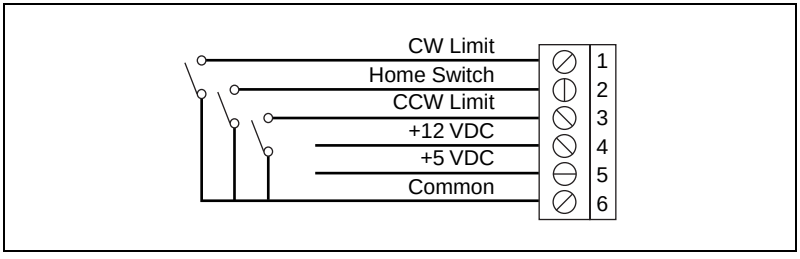


Figure 8. Pin Assignment for the Passive Limit Switch Terminal Block on the ValueMotion nuDrive

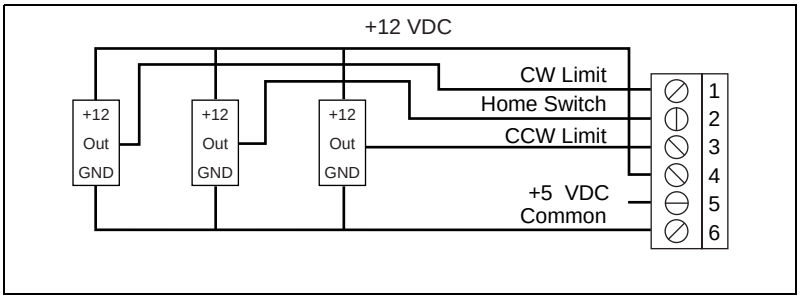


Figure 9. Pin Assignment for the Active Limit Switch Terminal Block on the ValueMotion nuDrive

FlexMotion Configuration

On FlexMotion nuDrives, the per-axis High-Speed Capture input signal is available on pin 4 of each limit switch terminal block. Pin 5 provides an External Inhibit input signal for remotely inhibiting the nuDrive axis. All limit signals are filtered in the nuDrive and debounced on the FlexMotion board to reduce noise sensitivity. The FlexMotion nuDrive and board provide for optically isolated limit switch inputs, and pin 6 is the isolated (ISO) Common signal connection. Refer to Figure 10 for the FlexMotion terminal block pin assignments.

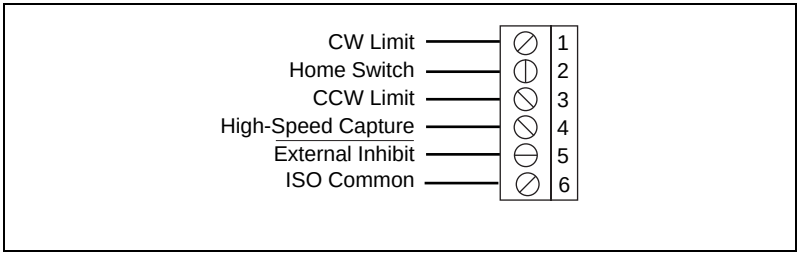


Figure 10. Pin Assignment for the Limit Switch Terminal Block on the FlexMotion nuDrive

The Limit, High-Speed Capture, and External Inhibit signals are opto-coupled inputs and require an external isolated voltage source. Alternatively, you can use the +5 V and ground signals on the host computer by properly setting a jumper to connect the isolated voltage (input) to 5 V and the ISO Common signal on the FlexMotion board. Refer to the *FlexMotion User Manual* for more information. Refer to the *I/O Terminal Block* section of this guide for more information on the FlexMotion isolated input connection.

Caution ***The FlexMotion board will be damaged if the isolated voltage selection jumpers on the FlexMotion board are set to use the internal voltage source and an external source is connected directly to these signals on the nuDrive. Be careful to review***

the configuration of the isolated voltage jumper section prior to powering any FlexMotion circuits or the host PC containing the FlexMotion board.

I/O Terminal Blocks

I/O connector configurations differ for ValueMotion and FlexMotion nuDrives. Refer to the appropriate section for more information on configuring your motion control board with the nuDrive accessory.

ValueMotion Configuration

For ValueMotion, general-purpose digital I/O lines are provided to augment the motion signals. The I/O lines are organized into two separate I/O connectors, with each group using a separate six-position terminal block with removable screws. When used in conjunction with a ValueMotion board, each I/O line is internally pulled up to +5 V through 3.3 kΩ resistors on the motion control board and can be individually configured as inputs or outputs by jumper configuration on the ValueMotion board. When configured as outputs, the current sinking capability is 60 mA per bit. Figure 11 shows the two six-position I/O terminal block pin assignments.

☞ **Note** ***When connected to a ValueMotion stepper board, I/O pins 5 through 8 are used for axis inhibit outputs 1 through 4 respectively.***

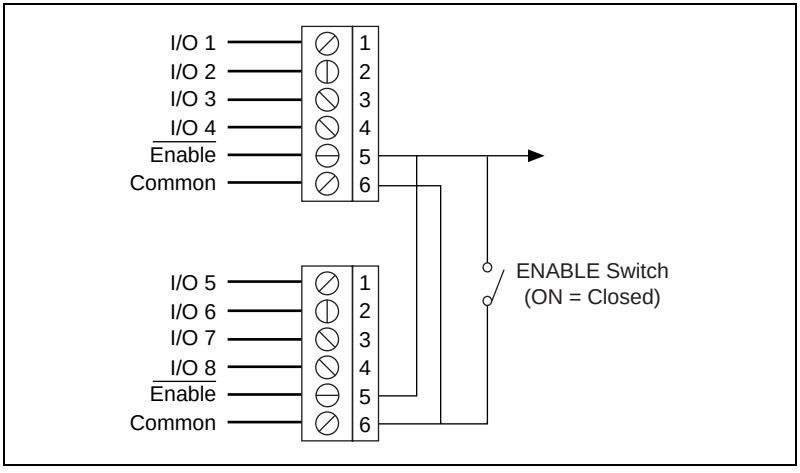


Figure 11. Pin Assignments for the Two Six-Position I/O Terminal Blocks on the ValueMotion nuDrive

The ENABLE switch, located on the front panel of your ValueMotion nuDrive, controls the enable signal input. The active-low enable signal input is also available on pin 5 of each I/O terminal block and can remotely enable all axes in the nuDrive. You can use either enable input on the I/O

terminal blocks OR the front panel ENABLE switch to enable the nuDrive accessory. E-stop inputs and the host bus interlock also affect the ENABLE function.

Notes ***The front panel ENABLE switch is wired in parallel to the active-low enable signal of the I/O connector. To use the enable signal in the I/O connector(s), the front panel ENABLE switch must be off (not illuminated).***

The ENABLE switch is illuminated whenever it is switched on. It will not indicate that the amplifiers/drivers are disabled under the following conditions: E-Stop (see the *E-Stop Terminal Block* ***section), Host Bus interlock fault, or amplifier/driver protection fault. Conversely, it will not light if the external Enable function is used via the I/O terminal blocks.***

FlexMotion Configuration

There are two I/O connectors (upper and lower) on the FlexMotion nuDrive. Each I/O connector uses a six-position removable screw terminal block. The upper terminal block provides access to four channels of ±10 V A/D converter analog input as well as analog reference voltage output from the converter circuit and reference common signal connections. The lower terminal block provides access to breakpoint output digital I/O signals as well as an isolated external power supply voltage input connection. Refer to Figures 12 and 13 for the upper and lower FlexMotion-compatible I/O terminal block pin assignments.

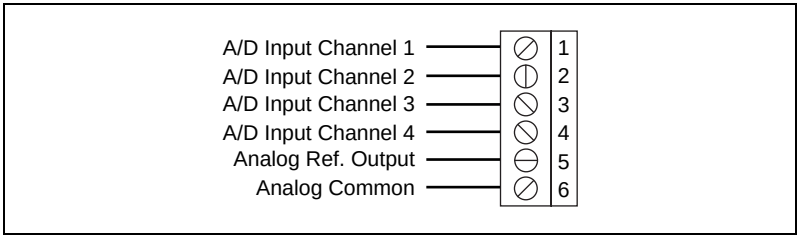


Figure 12. Upper I/O Terminal Block Pin Assignment on the FlexMotion nuDrive

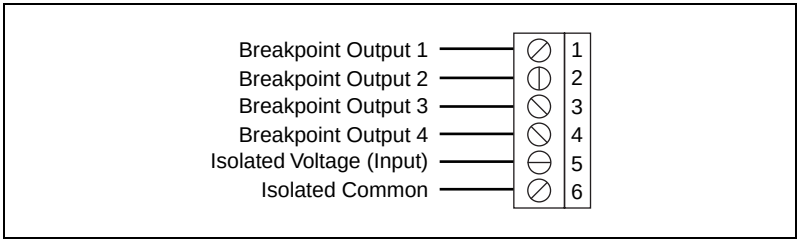


Figure 13. Lower I/O Terminal Block Pin Assignment on the FlexMotion nuDrive

The breakpoint output digital signals are opto-coupled outputs and require an external isolated voltage source connected to the isolated voltage and

isolated common inputs. Alternatively, you can use the +5 V and ground signals on the host computer by setting a jumper to connect the isolated voltage (input) to 5 V and the ISO Common signal to ground on the FlexMotion board. Refer to the *FlexMotion User Manual* for more information.

Amplifier/Driver Command Signals

Servo Amplifier Signals

The servo amplifiers used in the servo versions of nuDrive accept an industry-standard ±10 V analog torque (current) command signal. Servo motion control boards used with the nuDrive provide this standard output and are programmed to close both the velocity loop and position loop using an enhanced PID algorithm.

Stepper Driver Signals

For stepper drivers, there are two industry standards for command signals:

- Step and Direction signals (nuDrive standard)
- Independent CW and CCW pulses

The nuDrive uses stepper drivers that have active low step and direction inputs. You must configure the stepper outputs of your ValueMotion stepper controller for Step and Direction signals with inverted (active low) polarity. This configuration is the National Instruments default output configuration for stepper controller boards and nuDrives.

Optional Configurations

Warning ***Be sure to turn off the enable switch and disconnect the main AC power as well as the E-Stop 115 VAC input from the nuDrive before opening the nuDrive cover, or accessing any components within the nuDrive.***

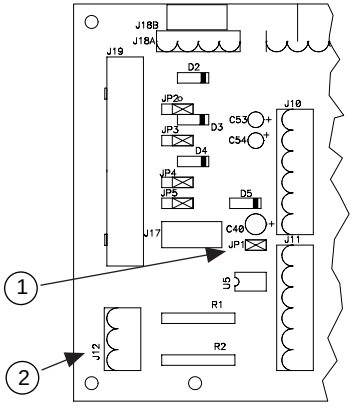
This section describes optional configurations for your nuDrive accessory. nuDrive is factory configured with default settings appropriate for many applications. If required, you can modify the parameters and settings on the individual axis drivers to meet your specific application requirements.

E-Stop Terminal Block

The E-Stop option has a separate three-position removable screw terminal block on the nuDrive back panel.

Note ***Your nuDrive is shipped with the E-Stop disabled. To enable the E-Stop, remove the jumper from JP1 located on the interface board inside the nuDrive. JP1 is the single two-pin header near the E-Stop 3 position terminal block.***

Figure 14 shows the location of the E-Stop terminal block (and E-Stop configuration jumper) on the interface board.



1 JP1 2 E-Stop

Figure 14. E-Stop Location

If you enable the E-Stop option, you must apply a 115 VAC signal to pins 1 and 3 in addition to the normal nuDrive enable (ENABLE switch or I/O connector enable input, if applicable) for the nuDrive's amplifiers/drivers to be enabled (not inhibited). If you disconnect the 115 VAC with the E-Stop option selected, the amplifiers/drivers are immediately disabled (inhibited) regardless of the status of the ENABLE switch or enable input. Refer to Figure 15 for more information on the E-Stop terminal block pin assignment.

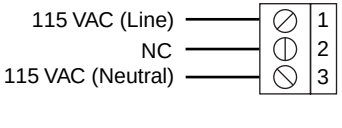


Figure 15. E-Stop Terminal Block Pin Assignment

Note ***The front panel ENABLE switch will remain illuminated even when the 115 VAC signal is removed from the E-Stop connector, disabling the axes.***

Servo Amplifier Configurations

The servo nuDrive uses high-efficiency PWM amplifiers configured as torque blocks (current amplifiers or transconductance amplifiers). The amplifier peak and continuous current limits and the current gain have been factory set for 5 A continuous and 10 A peak current output. Verify that these settings are appropriate for your application before powering your motors.

You can adjust the current limits and current gain by changing the values of R6, R7, R40, and R42 on the servo amplifiers. The resistors are standard ¼ W axial leaded type and are plugged into sockets on the PWM per axis servo drives.

Caution ***Do not solder or unsolder the resistors on the servo amplifiers. Trim the leads to the proper length, bend them at 90°, and plug them into the sockets.***

Refer to the following formulas to help you calculate the resistor values.

$$\text{Icont (nom.)} = 8\ \text{A},\ \text{Ipeak (nom.)} = 20\ \text{A}$$

$$\text{Gain (A/V)} = (6.6/R6,7) \times \text{Ic (nom.)} = (6.6/R6,7) \times 8 = 53/R6,7\ (\text{in K}\Omega)$$

$$Q = \text{Icont/Icont (nom.)} = \text{Icont}/8$$
$$R40\ (\text{in k}\Omega) = 2 \times Q/(1-Q) \Rightarrow Q = R40/(2+R40)$$

$$P = \text{Ipeak/Ipeak (nom.)} = \text{Ipeak}/20$$
$$R42\ (\text{in k}\Omega) = 10 \times P\ (1-P) \Rightarrow \quad P = R42/(10+R42)$$

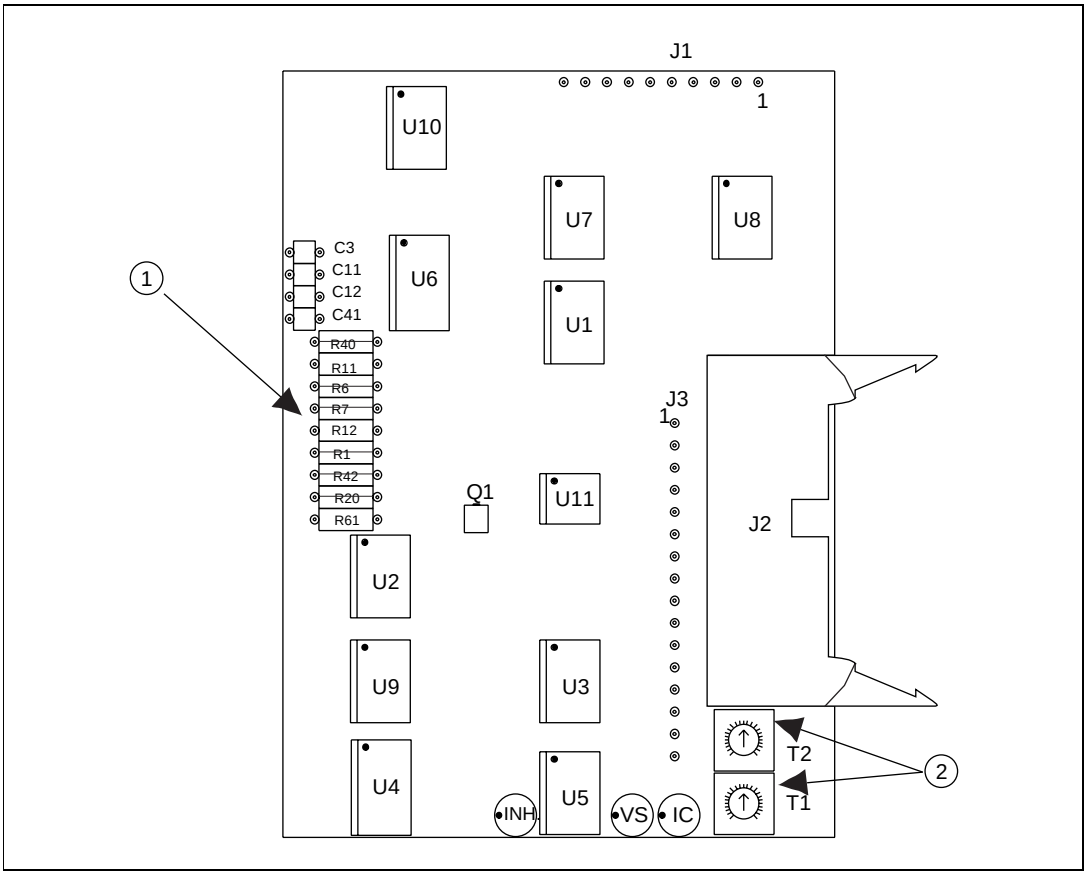
Table 2 lists the factory-default resistor values and gives examples of possible current gain and current limit resistor values for various applications. Please note that some components are missing from their sockets. These components were removed at the factory to configure the amplifier as a torque (current) block.

Table 2. Current Gain and Current Limit Resistor Values

Current	Default	Example 1	Example 2	Example 3
Gain	1.1 A/V	1.1 A/V	1.6 A/V	1.1 A/V
Ipeak	10 A	6.4 A	15 A	3 A
Icont	5 A	2.7 A	6.7 A	0.73 A
Resistor Location				
R40	3.3 kΩ	1 kΩ	10 kΩ	200
R6 and R7	47.5 kΩ 1%	47.5 kΩ 1%	33 kΩ 1%	47.5 kΩ 1%
R1	100 kΩ	100 kΩ	100 kΩ	100 kΩ
R42	10 kΩ	4.7 kΩ	33 kΩ	1.8 kΩ
R20	100 kΩ	100 kΩ	100 kΩ	100 kΩ

The balance (DC offset) of the amplifier is trimmed to zero at the factory. If you change the current gain and/or current limits settings, it may be necessary to balance the amplifier again. If any motor tends to rotate slowly after it is killed by the ValueMotion or FlexMotion servo controller, you may need to balance the corresponding amplifier.

Figure 16 shows the location of the resistors and trimpots on your SSA-8/100 board.



1 Resistors	2 Trimpots

Figure 16. Servo Amplifier Parts Locator Diagram

Warning ***You can only adjust the balance while the nuDrive is powered and the amplifier is enabled. Use extreme caution and adjust the trimpot with a plastic trimpot screwdriver designed for the task. High voltages and currents exist within a powered nuDrive. Do not attempt to make this adjustment unless you are qualified to do so.***

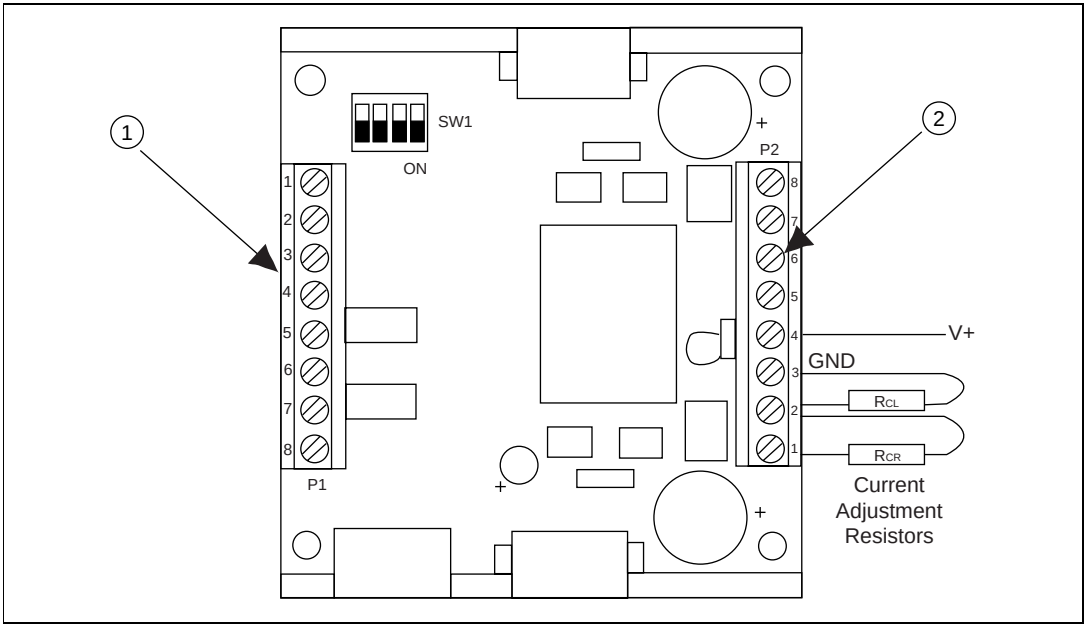
Carefully adjust trimpot T2 on the servo amplifier until the motor ceases to rotate.

The amplifiers in the servo nuDrive also have three status LEDs that are useful for troubleshooting potential amplifier faults. The amber LED (labeled **VS**) indicates the presence of DC bus power and should be illuminated whenever the nuDrive is powered on. The center red LED is the

overcurrent indicator (labeled **IC**) which should never be illuminated. If it is, check the motor cabling for short circuits between the motor leads and/or short circuits to ground at or around the motor. The third red LED is located slightly separate from the other two. This is the inhibit status LED (labeled **INH**). If a motor does not move when commanded and this LED is on, check that the nuDrive is enabled via the enable switch, host interlock and external inhibit inputs, and not in an E-Stop condition.

Microstepping Driver Configurations

The stepper nuDrive uses bipolar chopper two phase microstepping drivers with a broad range of possible microstep ratios and current output settings. The factory-default settings are 10-times microstepping (2,000 steps/rev with standard 1.8° stepper motors) and current limits set to approximately 1 A RMS (1.4 peak) per phase. All microstep drivers in the nuDrive have an automatic current reduction mode when not stepping to minimize motor heating. The microstep drivers are factory set to default to 50% of the peak current value when no stepping has occurred for at least about 500 ms. Figure 17 shows the location of the P1 and P2 terminal blocks and shows where you connect the current adjustment resistors on your Intelligent Motion Systems (IMS) board.



1 P1 2 P2

Figure 17. Stepper Driver Parts Locator Diagram

Stepper Motor Current

You can modify the current limit and current reduction settings by changing the values of the current limit resistor (R_{CL}) and current reduction resistor (R_{CR}) on the stepper driver's P2 terminal block.

Refer to the following formula to help you calculate the R_{CL} and R_{CR} resistor values.

$$\text{Output Current (Peak)} = 0.002 \times R_{CL}$$
$$[\text{Output Current (RMS)} = 0.707 \times 0.002 \times R_{CL}]$$

$$\text{Current @ Reduction (Peak)} = 0.002 \times (R_{CL} \,||\, R_{CR}) \text{ (resistors in parallel)}$$
$$= \text{Output Current} \times R_{CR}/(R_{CL} + R_{CR})$$

Table 3 lists the RMS and peak currents for standard values of R_{CL} (5% type 1/4 W resistors).

Warning ***A Current Limit resistor (R_{CL}) is always required to keep the drive in a safe operating condition. Be sure to use a current limit resistor with a value no greater than 2.0 kΩ.***

Table 3. Output Current versus R_{CL} Value

Output Current (per Phase)		
RMS	**Peak**	**R_{CL} Value (5%, 1/4 W)**
0.26 A	0.36 A	180 Ω (Minimum Value)
0.31 A	0.44 A	220 Ω
0.38 A	0.54 A	270 Ω
0.47 A	0.66 A	330 Ω
0.55 A	0.78 A	390 Ω
0.65 A	0.95 A	470 Ω
0.8 A	1.1 A	560 Ω
1.0 A	1.4 A	680 Ω (Factory Default)
1.2 A	1.6 A	820 Ω
1.4 A	2.0 A	1.0 kΩ
1.7 A	2.4 A	1.2 kΩ
2.1 A	3.0 A	1.5 kΩ

Table 3. Output Current versus R_{CL} Value (Continued)

Output Current (per Phase)		
RMS	**Peak**	**R_{CL} Value (5%, 1/4 W)**
2.5 A	3.6 A	1.8 kΩ
2.8 A	4.0 A	2.0 kΩ (Maximum Value)

Microstep Selection

The microstepping drivers in your stepper nuDrive have a DIP switch for setting the microstep ratio. Table 4 shows the DIP switch settings for all possible microstep configurations.

Table 4. Microstep Ratio DIP Switch Setting

Binary Selections	
Switch	**Microsteps/Step**
	2 (Half Step)
	4
	8
	16
	32
	64
	128
	256

Decimal Selections	
Switch	**Microsteps/Step**
	5
	10 (Factory Default)
	25
	50
	125
	250
	Do not use
	Do not use

Stepper Motor Configurations

This section describes the various industry-standard winding configurations for stepper motors and shows how to connect them to a stepper nuDrive. The nuDrive is compatible with all configurations of two-phase stepper motors.

Note ***The stepper nuDrive is not compatible with five-lead unipolar stepper motors or five-phase stepper motors; the stepper nuDrive is only compatible with 2-phase type stepper motors.***

Two-phase stepper motors come in 4-, 6-, and 8-wire variations. Figure 18 shows a 6-wire and an 8-wire stepper motor respectively. A 4-wire motor is the same as a 6-wire motor except that the center taps (CT) are not brought out.

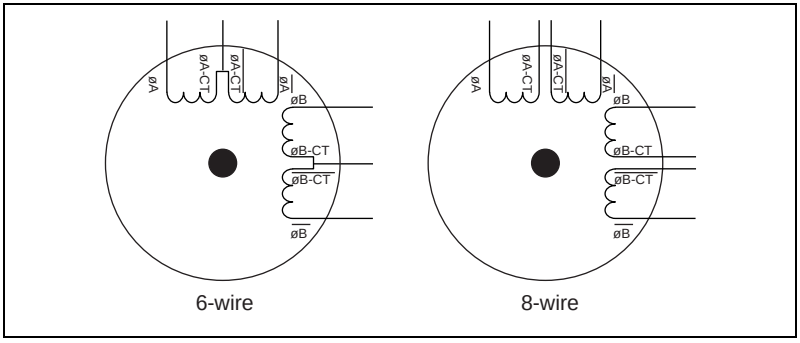


Figure 18. 6-Wire and 8-Wire Stepper Motors

For maximum flexibility, you can connect 8-wire stepper motors in either a series or parallel configuration. Connecting the windings in series as shown in Figure 19 produces the most torque per amp, but has the disadvantage of higher inductance and poorer high-speed performance.

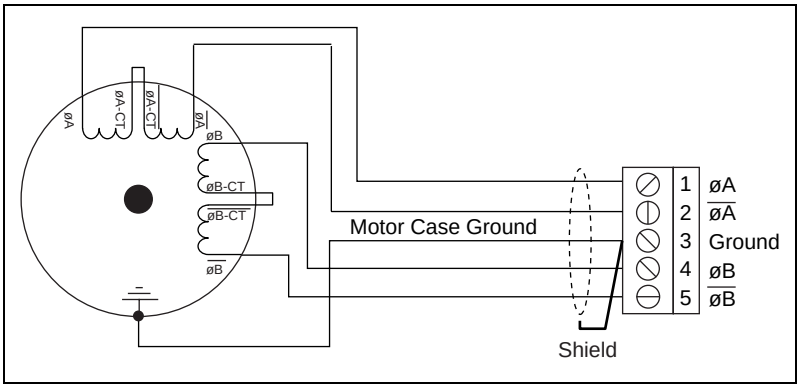


Figure 19. Series Stepper Motor Wiring (Higher Torque, Lower Speed)

Alternatively, 8-wire stepper motors can be wired in parallel as shown in Figure 20. This configuration produces better high-speed performance but requires more current to produce rated torque.

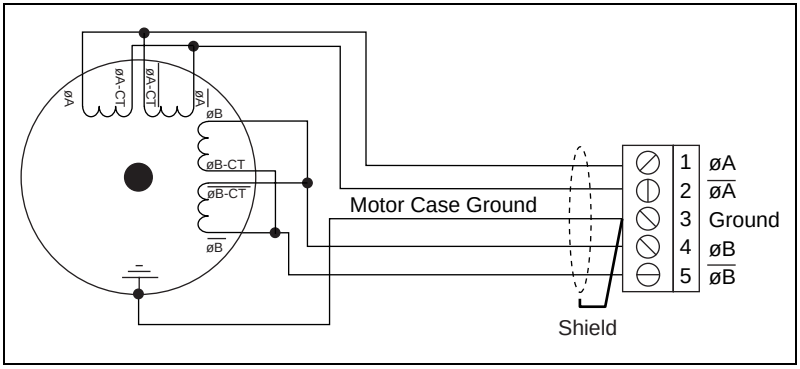


Figure 20. Parallel Stepper Motor Wiring (Higher Speed, Lower Torque)

Notice that an 8-wire motor wired in series is virtually identical to a 6-wire motor and typically has the same high-torque but low-speed characteristics. While a parallel configuration is not possible with a 6-wire motor, high-speed performance can usually be obtained with the half-coil connection shown in Figure 21. This configuration sacrifices low-speed torque for better high-speed performance. With this configuration, it is typically not possible to produce the rated torque of the motor without the risk of the motor overheating because only half of the windings are being used.

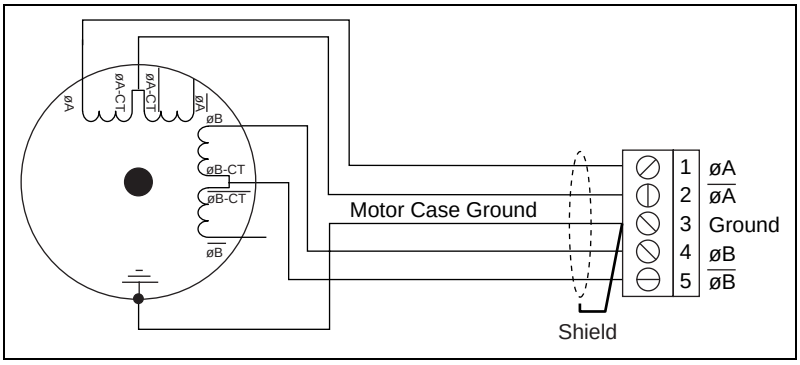


Figure 21. Half-Coil Stepper Motor Wiring

Figure 22 shows the wiring for a typical 4-wire motor.

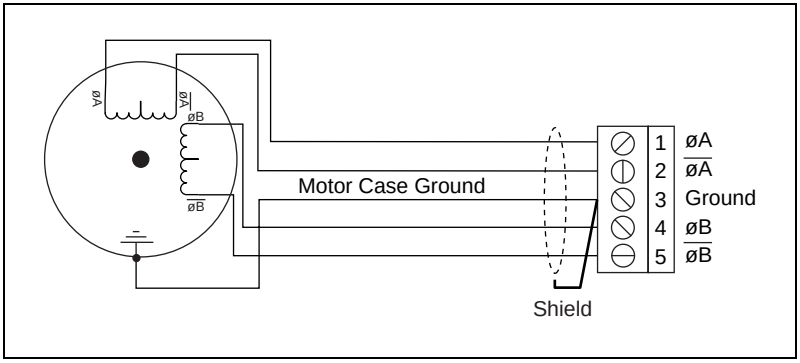


Figure 22. 4-Wire Motor Wiring

Specifications

Servo Amplifiers (Standard Type SSA 8/100)

Peak current (2 s) ..... 20 A (default limit 10 A)

Continuous current ..... 8 A (default limit 5 A)

DC-bus motor voltage ..... 48 VDC (RMS)

PWM frequency ..... 20 kHz

Stepper Drivers (Standard Type IM483)

Current per phase ..... 0.26 to 2.8 A RMS (default limit 1 A RMS) (0.36A to 4.0 A peak)

Type ..... Bipolar chopper

Motor bus voltage ..... 24 or 40 V

Microstepping selections ..... ×2, 4, 8, 16, 32, 64, 128, 256 ×5, 10, 25, 50, 125, 250 (default is 10 times)

Encoder Interface (Each Axis)

Inputs ..... Quadrature with index

Type ..... Differential or single-ended TTL

Voltage range ..... 0–5 VDC

Noise filter ..... 1 µs (1 MHz)

Limit and Home Switch Inputs (Each Axis)

ValueMotion

- Voltage range ..... 0–12 VDC
- Voltage threshold ..... TTL
- Noise filter ..... 10 µs (100 kHz)

FlexMotion ..... Refer to the *FlexMotion User Manual* for isolated and non-isolated signal specifications.

Configurable I/O

ValueMotion

- Input voltage ..... 0–5 VDC (TTL)
- Voltage threshold ..... TTL
- Output voltage ..... 0–5 VDC
- Output current ..... 60 mA sink max

FlexMotion ..... Refer to the *FlexMotion User Manual* for isolated and non-isolated signal specifications.

Connectors (Included)

Encoders ..... 8-pin terminal blocks (1 per axis)

Limits ..... 6-pin terminal blocks (1 per axis)

Motor ..... 5-pin terminal blocks (1 per axis)

I/O ..... 6-pin terminal blocks (2 total)

E-Stop ..... 3-pin terminal block (1 total)

AC power ..... Detachable AC power cord (IEC standard type)

Safety

Installation Category II, Pollution Degree 2

Environment

Operating temperature ..... 0° to 45° C

Storage temperature ..... –25° to 70° C

Humidity ..... 10 to 90% (noncondensing)

Altitude ..... < 2,000 m

Power Supply

Input voltage ..... 115 VAC ±15%, 50-60 Hz

Input Fuse

24 VDC units ..... F5 (5 A, 5 × 20 mm)

40 and 48 VDC units..... F10 (10 A, 5 × 20 mm)

Host Bus Voltage Interlock

PC bus host voltage
monitoring range..... 5 VDC ±5%

Dimensions

Width..... 42.9 cm (16.9 in.)
48.3 cm (19.0 in.) with
rack-mounting flanges

Height..... 13.2 cm (5.2 in.) (3 U type)

Depth..... 30.5 cm (12 in.)

Weight..... 20–35 lb (depending on model)

nuDrive Cables for Standard Tables

This section lists cabling and interface information for typical linear, x/y, and rotary tables from major manufacturers. While the information is believed to be complete and accurate, pin assignment configurations and wire colors can change depending upon options and configurations of the tables. Please consult the table manufacturer's wiring information in conjunction with this section.

Caution ***Incorrect wiring may lead to loss of table control and subsequent damage to the motors, limit switches, and/or mechanical structure. Please confirm the wiring before powering the nuDrive.***

Table 5. Typical nuDrive Cabling for Newport/Klinger Tables

nuDrive Pin No.	Signal	Jaeger Pin No.
All Klinger Scientific Tables with 19-Pin Jaeger Connectors		
Encoder 1	Encoder A	13
Encoder 2	Encoder A*	17
Encoder 3	Encoder B	14
Encoder 4	Encoder B*	18
Encoder 5	Index Pulse	9
Encoder 6	Index Pulse*	19

Table 5. Typical nuDrive Cabling for Newport/Klinger Tables (Continued)

nuDrive Pin No.	Signal	Jaeger Pin No.
Encoder 7	+5 V	15
Encoder 8	0 V Logic	16
Encoder 8	Encoder Cable Shield	No Connect
Limit 1	End of Run +	11
Limit 2	Signal Origin	7
Limit 3	End of Run –	12
Limit 4 and 5	No Connect	—
Limit 6	0 V Logic	10
Klinger Scientific Tables with UE 72 CC Servo Motor		
Motor 1	Motor +	3
Motor 2	Motor –	4
Motor 3	Case Ground	8
Motor 3	Motor Cable Shield	No Connect
Klinger Scientific Tables with UE 30 CC Servo Motor		
Motor 1	Motor +	5
Motor 2	Motor –	6
Motor 3	Case Ground	8
Motor 3	Motor Cable Shield	No Connect
Klinger Scientific Tables with Stepper Motors		
Motor 1	Winding A Start	1
Motor 2	Winding A End	2
Motor 3	Case Ground	8
Motor 3	Motor Cable Shield	No Connect
Motor 4	Winding B Start	3
Motor 5	Winding B End	4
*Signal is active-low.		

Table 6. Typical nuDrive Cabling for New England Affiliated Technologies (NEAT) Tables

nuDrive Pin No.	Signal	DE-9S Conn	NEAT Cable Color[1]
NEAT Tables with Encoders			
Encoder 1	Encoder Channel A	Limit 6	Blue
Encoder 2	Encoder Channel A[2]	Limit 8	Green
Encoder 3	Encoder Channel B	Limit 7	White
Encoder 4	Encoder Channel B[2]	Limit 9	Violet
Encoder 5	Index (Special Option)	Limit 4	Brown
Encoder 6	No Connect	—	—
Encoder 7	+ 5 V	Limit 1	Red
Encoder 8	Ground	Limit 5	Black
Encoder 8	Encoder Cable Shield	No Connect	Drain
Limit 1	+ Limit Output	Limit 2	Yellow
Limit 2	– Limit Output	Limit 3	Orange
Limit 3	No Connect[3]	—	—
NEAT Tables without Encoders			
Limit 1	+ Limit Output	Limit 2	Yellow
Limit 2	No Connect	—	—
Limit 3	– Limit Output	Limit 3	Orange
Limit 4	+ 5 V [4]	Limit 1	Red
Limit 5	No Connect	—	—
Limit 6	Ground	Limit 5	Black
NEAT Tables with Servo Motors			
Motor 1	Motor +V	Motor 1	Red
Motor 2	Motor –V	Motor 6	Black
Motor 3	Motor Cable Shield	No Connect	Drain
NEAT Tables with Stepper Motor (Half-Coil Connection) (Recommended configuration for low-torque, high-speed applications)			
Motor 1	Phase 1 (A Start)	Motor 1	Red

Table 6. Typical nuDrive Cabling for New England Affiliated Technologies (NEAT) Tables (Continued)

nuDrive Pin No.	Signal	DE-9S Conn	NEAT Cable Color[1]
Motor 2	Phase 1, 3 CT	Motor 6	Black
Motor 3	Motor Cable Shield	No Connect	Drain
Motor 4	Phase 2 (A Start)	Motor 4	Green
Motor 5	Phase 2, 4 CT	Motor 9	Brown
NEAT Tables with Stepper Motors (Full-Coil Connection)			
Motor 1	Phase 1 (A Start)	Motor 1	Red
Motor 2	Phase 3 (A End)	Motor 2	Orange
Motor 3	Motor Cable Shield	No Connect	Drain
Motor 4	Phase 2 (B Start)	Motor 4	Green
Motor 5	Phase 4 (B End)	Motor 5	Blue

[1]While the information is believed to be complete and accurate, pin assignment configurations and wire colors can change depending upon options and configurations.

[2] Signal is active-low.

[3]The –Limit Output signal can alternately be wired to nuDrive Limit 3 (CCW Limit).

[4] The NEAT Limit Switches are Hall-Effect type and can be powered with either +5 V or +12 V. In encoder configurations, power for both the limit switches and the encoders is +5 V from the nuDrive Encoder 7 connection.

Table 7. Typical nuDrive Cabling for Design Components Inc. (DCI) Tables

nuDrive Pin No.	Signal
Encoder 1	Encoder A
Encoder 2	Encoder A*
Encoder 3	Encoder B
Encoder 4	Encoder B*
Encoder 5	Index
Encoder 6	Index*
Encoder 7	+5 V
Encoder 8	Ground
Encoder 8	Encoder Cable Shield
Limit 1	Forward Limit

Table 7. Typical nuDrive Cabling for Design Components Inc. (DCI) Tables (Continued)

nuDrive Pin No.	Signal
Limit 2	Home Switch
Limit 3	Reverse Limit
Limit 4	+12 V
Limit 5	No Connect
Limit 5	Ground
DCI Tables with Servo Motors	
Motor 1	Motor +
Motor 2	Motor –
Motor 3	Case Ground
Motor 3	Motor Cable Shield
DCI Tables with Stepper Motors	
Motor 1	Winding A Start
Motor 2	Winding A End
Motor 3	Case Ground
Motor 3	Motor Cable Shield
Motor 4	Winding B Start
Motor 5	Winding B End
*Signal is active-low.	

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